A Cost-Effective Smart Irrigation System For Water Reduction

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Abstract **– A cost-effective solution for water reduction based on a smart irrigation system is presented in this paper. The system consists of a microcontroller, moisture sensors, relays, solenoid valve and water pump. Depending on the conditions of a specific location (soil condition – wet, dry, etc.) the system can control the amount of used water by modifying some parameters. In this application were considered 2 zones which mean that 2 humidity sensors were used. When the humidity drops below a threshold value on one of the two zones, the corresponding humidity sensor transmits the information to the controller, opens the solenoid valve and starts the water pump until the humidity reaches at the preset value. If humidity decreases in the meantime on the other zone the information received from the humidity sensor leads the solenoid valve to open and the pump starts until the desired humidity is attained. When the humidity is over the threshold value, the system is in "stand-by" until the sensors send new information to the microcontroller and thus the system resumes its operating cycle. In this way various crops can be watered without using a high quantity of water. In addition, a smartphone application was used in order to provide to the user information about the soil condition. In order to implement this solution, a laboratory model was constructed and experimental results were performed to test the performance of the irrigation system.**

Cuvinte cheie: *controller, managementul apei, sistem de irigare inteligent, senzor de umiditate.*

Keywords: *controller, water management, smart irrigation system, humidity sensor.*

I. Introduction

Water Management is of a paramount importance since it helps determine future Irrigation expectations and remains a precious resource not only in dry regions but also in many other parts of the world. Therefore, it must be managed carefully and with maximum efficiency. Although there are many proposed solution regarding irrigation systems, there is still a waste of water with consequences on power consumption.

Many researchers have tried to address the issue. In [1] it is presented a smart irrigation system that uses information from environment to determine when and where irrigation is needed. The efficiency of the solution is given by the transmission of water to dry locations of the field.

In [3] it is presented a system which prioritizes irrigation operation by determining the number of pumps to be operated at any instance as well as their locations.

As a result, specific crops can be watered in dependence on their water necessity. Several authors utilize water management systems based on PLC or microcontroller [1], [2], [3]. Other solutions are presented in [4] - [8].

Recently, smart phone applications have been developed that schedule irrigation using real-time weather data. In [8] is presented is developed an easy-to-use and engaging irrigation scheduling tool for cotton which operates on a smart phone platform. The model which drives the Cotton Smart Irrigation App (Cotton App) is an interactive ET-based soil water balance model. The Cotton App uses meteorological data from weather station networks, soil parameters, crop coefficients, and irrigation applications to estimate root zone soil water deficits in terms of percent as well as of inches of water.

Some authors were comparing a Smartphone Irrigation Scheduling Application with Water Balance and Soil Moisture-based Irrigation Methods [9]. More exactly, a new smart phone irrigation scheduling application (VegApp) was compared with current irrigation scheduling recommendations and an automated soil moisture sensor (SMS)–based irrigation system in southern Georgia during Spring 2016 and 2017. Plants were grown using plastic mulch and drip irrigation following standard production practices for watermelon (Citrullus lanatus) in Georgia. The VegApp irrigation regime was based on evapotranspiration (ETo) values calculated from real-time data collected from a nearby weather station.

This paper proposes a system which consists of a microcontroller, moisture sensors, relays, solenoid valve and water pump. The system can control the amount of used water by modifying some parameters depending on the conditions of a specific location (soil condition). For this solution were considered 2 parts which means that 2 humidity sensors were used. When the humidity drops below a threshold value on one of the considered zones, the corresponding humidity sensor transmits the information to the controller, opens the solenoid valve and starts the water pump until the humidity reaches at the preset value. If humidity decreases in the meantime on the other zone the information received from the humidity sensor leads the solenoid valve to open and the pump starts until the desired humidity is attained. In case when the humidity is over the threshold value, the system will be in "stand-by" mode until the sensors send new information to the microcontroller and thus the system resumes its operating cycle. Moreover, a smart phone application was used in order to provide the user with the information about the soil condition.

To implement this solution, a laboratory model was constructed and experimental results were performed to test the performance of the irrigation system.

II. SYSTEM CONFIGURATION

A. Block Diagram

The block diagram of the proposed irrigation system is presented in Figure 1. The circuit receives the power supply in the form of voltage (5V DC power) and the water content of the soil is measured by humidity sensors. Finally, these measured values are sent to the controller as an analog input. Two solenoid valves are controlled by the control module.

The relays module has an interface that can be controlled directly by the microcontroller. This element is optically isolated from the high voltage side for safety requirements.

The power source receives 6-12V at the input and supplies 3 or 5 V on each of the two outputs. It uses 2 voltage regulators and provides an output current of up to 1A.

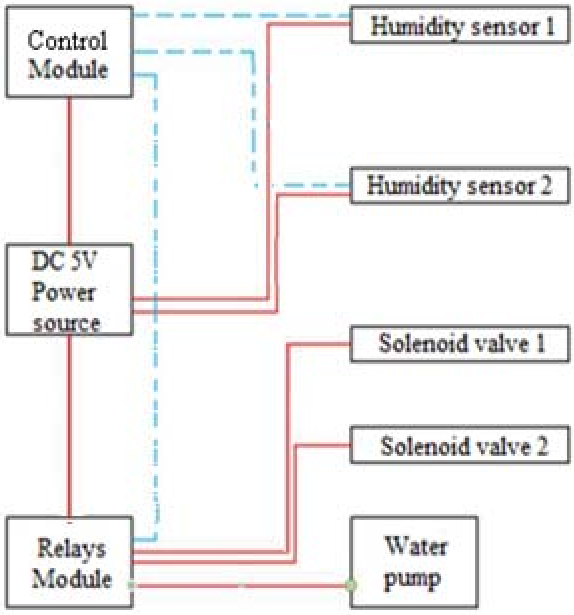

Fig. 1. Block diagram of the irrigation system

B. Irrigation system architecture

The controller interfaces with various devices such as relays module, humidity sensors, control module, solenoid valve and water pump.

When the soil humidity drops below a preset value, then it is the moment when the information is transmitted to the microcontroller, the solenoid valve opens and the water pump is ON.

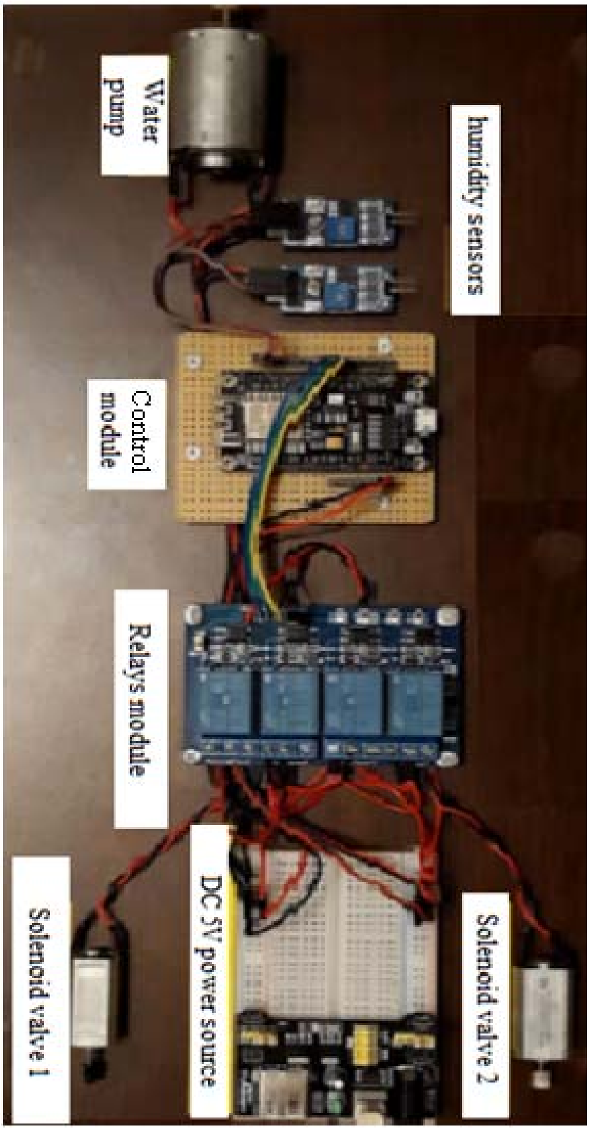

Fig. 2. Irrigation system architecture

The humidity sensor module and its electronic scheme are presented in Figure 3. The soil moisture sensor consists of two pieces which allow the current to pass through the soil.

The humidity is measured by reading the resistance value. When there is more water there will be a low value resistance and the moisture level will be higher.

If the humidity value is over the threshold value, the system will enter in “stand-by” mode until the sensors send new information to the microcontroller and thus the system resumes its operating cycle.

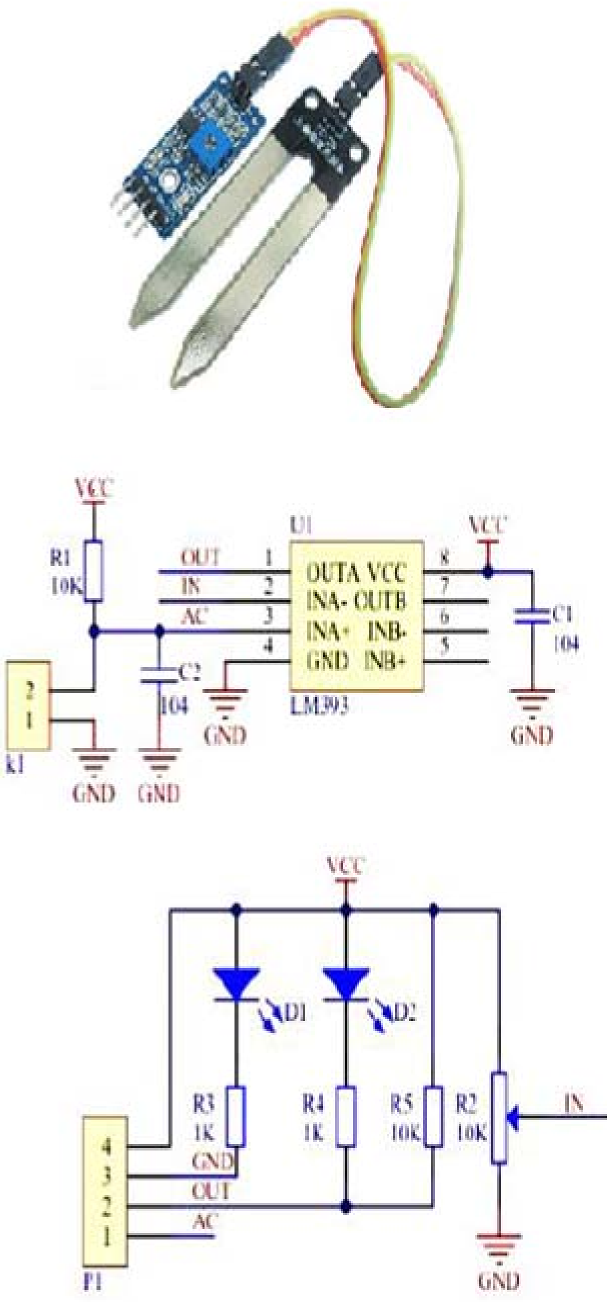

Fig. 3. Humidity sensor architecture

The humidity sensor module need a DC power 3.3 – 5 V and an electrical current over 100 mA. When the humidity drops below a threshold value on one of the two zones, the corresponding humidity sensor transmits the information to the microcontroller, opens the solenoid valve and starts the water pump until the humidity reaches at the preset value. If humidity decreases in the meantime on the other zone the information received from the humidity sensor leads the solenoid valve to open and the pump starts until the desired humidity is attained.

In this way various crops can be watered without using a high quantity of water.

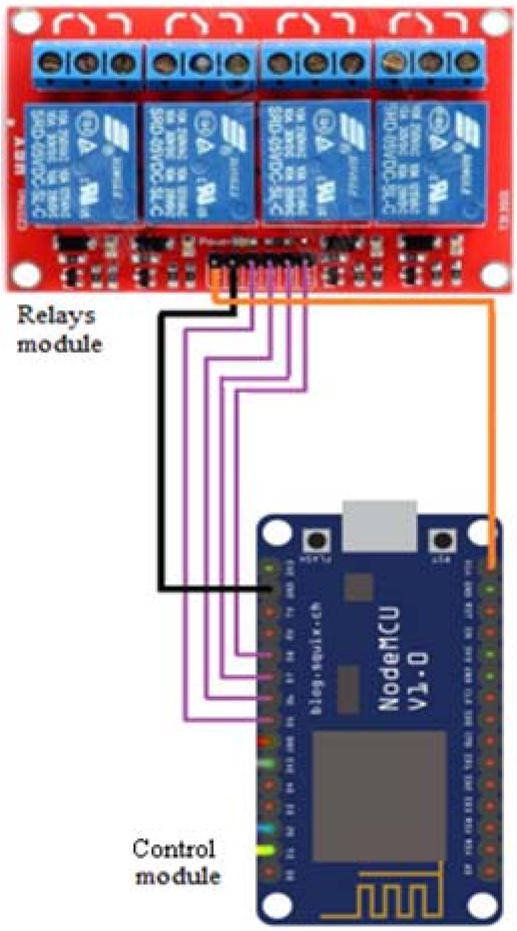

Fig. 4. Control module and relays module

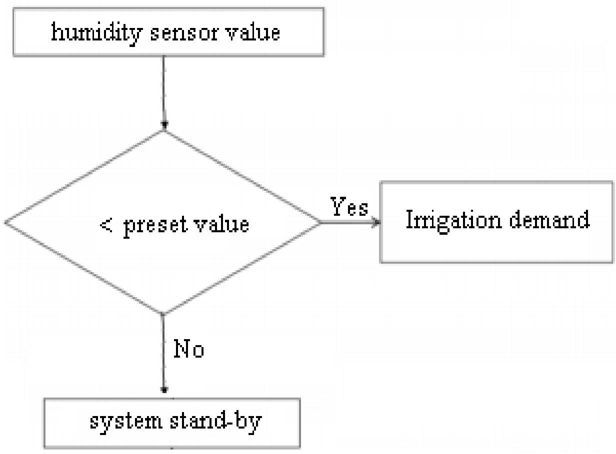

Fig. 5. System irrigation steps

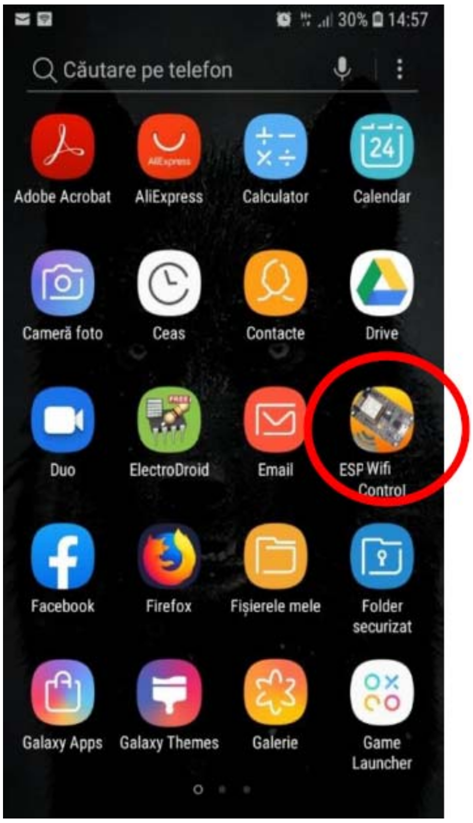

Fig. 6. Smart phone application Icon

Fig. 7. Smart phone application interface

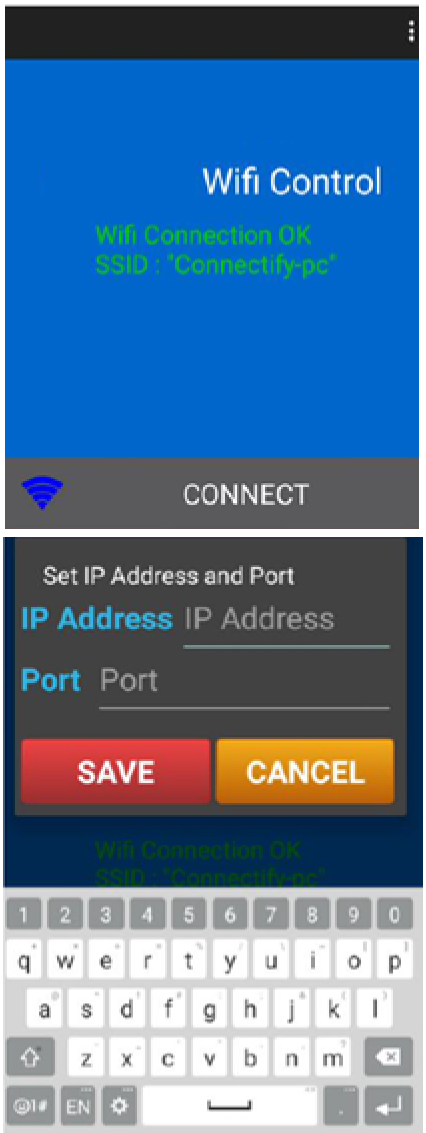

Fig. 8. Smart phone application settings

In order to manage and control the irrigation system a user-friendly smart phone app was utilized using a wi-fi control module (ESP8266 module). It is a simple and flexible application helping the user to get the control of irrigation system – viewing the soil condition (wet, dry, etc.), controlling the water pump.

III. Case Analysis

A significant part of Romania's agricultural area is experiencing the negative effects of drought, insufficient water reserves and poorly functional irrigation facilities. The absence or high degree of depletion of the irrigation infrastructure led to approximately 48 percent of the total agricultural area (7.1 million ha in 2006) being affected by these phenomena (the most affected areas were the Campia Romaneasca, southern Moldova and Dobrogea).

Old irrigation facilities generate a high water and energy consumption, which has a negative impact on Romania's water reserves, a country classified as low water reserves (the average water quantity available per capita is 2660 cubic meters water/place/year, including the Danube, just over half the European average 4230 cubic meters water/site/ year).

This solution based on controller ensures that water is adequately managed in the process of irrigation. It uses the humidity sensor to determine the value of humidity in the ground and transmits the information to the control module. Having this information the controller decides when the pump will be ON.

In order to test the proposed system for water reduction, tests were made on different soil samples with a moisture content of 25% and 65%, setting a threshold of 30 % for dry soil and 60 % for wet soil.

Consistent readings were taken in order to ensure the correct working of the sensors.

The case is outlined as shown in TABLE I.

TABLE I.
TESTING THE FUNCTIONALITY OF THE SYSTEM

Soil condition	**Humidity preset value [%]**	**Humidity measured value [%]**	**Relay status**	**Water pump status**
Dry	< 30	25	ON	ON
Wet	> 60	65	OFF	OFF

IV. CONCLUSION

Because water remains a precious resource not only in dry regions but also in many parts of the world it must be used carefully and with maximum efficiency.

A significant part of Romania's agricultural area is experiencing the negative effects of drought, insufficient water reserves and poorly functional irrigation facilities.

Old irrigation facilities generate a high water and energy consumption, which has a negative impact on Romania's water reserves, a country classified as low water reserves (the average water quantity available per capita is 2660 cubic meters water/place/year, including the Danube, just over half the European average 4230 cubic meters water/site/ year).

The proposed smart system for irrigation is a cost-effective solution based on microcontroller which can reduce the amount of water based on the crops needs. A microcontroller, humidity sensors, relays block and a water pump are the main components of the system.

Different parameters, i.e. humidity, make it possible to set the system depending to the needs of a specific location.

The system was tested in order to determine its functionality and it would be useful in places where water remains a challenge for the practice of irrigation.

In addition, a smart phone application was used in order to provide to the user information about the soil condition. In order to implement this solution, a laboratory model was constructed and experimental results were performed to test the performance of the irrigation system.

The entire system can be improved by using weather forecasts in irrigation scheduling.

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